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MAHONING RIVER INVESTIGATION. EFFECTS ON WATER QUALITY OF PROPOSED MAHONING-GRAND RIVER DIVERSION. APPENDIX IV

Public Health Service
Cincinnati, Ohio

June 1953

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MAHONING RIVER INVESTIGATION

Effects on Water Quality of Proposed Mahoning-Grand River Diversion

Prepared by

U. S. Department of
Health, Education, and Welfare
Public Health Service

Ohio and Tennessee Drainage Basins
Cincinnati, Ohio

Prepared at the request of and in cooperation with the District Engineer Pittsburgh District, Corps of Engineers

June 1953

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APPENDIX IV

Report by

U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

INTRODUCTION

This report has been prepared at the request of the District Engineer, Corps of Engineers, Pittsburgh, Pennsylvania. Essentially, it is a re-evaluation of a previous report "Effects on Water Quality of Proposed Mahoning-Grand River Diversion" prepared by the Public Health Service in December 1949. With respect to the requirements for organic pollution abatement, however, this whole problem has been restudied, using data obtained by the Ohio State Department of Health in a comprehensive stream sanitation study of the Mahoning River Basin extending over a period of several months (May to November, inclusive) in 1952. In addition, consideration has been given to reduction in industrial organic pollution which will result from waste treatment or plant process changes initiated primarily for the control of other types of pollution, such as suspended and floating solids and taste and odor producing substances.

The conclusions relating to organic pollution abatement contained herein have been based on the following considerations.

1. Domestic sewage:

   a. Secondary treatment can be expected to remove 90% of the biochemical oxygen demand (B. O. D.) without resorting to unusual or impractical sewage treatment processes.

   b. Intermediate treatment is presumed to remove 65% of the B. O. D.

2. Industrial Wastes:

   a. The major source of industrial wastes in the valley is from the steel industry. Measures required primarily to control pollution such as phenols and oils can reasonably be expected to reduce the present deoxygenating waste load now being discharged to the stream by at least 65%. This is borne out by Public Health Service studies of integrated steel mills and by-product coke plants.

3. Requirements of the State Water Pollution Control Agency: It is presumed that the newly created State Water Pollution Control Board will establish certain requirements applicable to all sources of pollution in the area, including the following:

a. A substantial reduction in the amounts of phenols now entering the stream from industrial operations.

b. Removal of floating and suspended solids from both domestic sewage and industrial wastes.

c. The construction of municipal sewage treatment works capable of removing at least 65% of the present domestic B. O. D. load. This will require facilities for chemical treatment as a minimum.

d. Industries having wastes amenable to treatment by usual sewage treatment processes will be expected to reduce present B. O. D. waste loads by 65%.

Pollution benefits resulting from further flow increases at Cincinnati, as reported in 1949, have been materially reduced because that city is now providing additional sewage treatment facilities the cost of which had been considered in estimating benefits of potential increased dilution. This does not infer that benefits previously credited to existing increased flows are similarly reduced.

The benefits for hardness reduction as reported in 1949 included savings in chemical costs for water softening at Warren. This item has been deleted in this report as Warren will soon abandon the Mahoning River and obtain its water supply from Mosquito Creek Reservoir. The new water treatment plant is now under construction.

Consideration was given to whether there have been substantial changes in the bases for estimating benefits to industry due to reduced water temperature, reduced maintenance repair and replacement, reduced hardness, and other secondary benefits primarily related to reduced water temperatures. After consultation between Corps of Engineers and industry representatives, it was concluded that the bases for estimating benefits for the 1949 report are appropriate for use in this review report. Accordingly, changes in the previously reported benefits are limited to adjustments by the Corps of Engineers to reflect June 1953 cost levels.

SUMMARY

The proposed Mahoning-Grand River Floodway and appurtenant works, together with existing reservoirs, would provide a comprehensive system for virtually complete flow regulation in the Mahoning River below Warren, Ohio. The development would make possible the routing of flood flows to a retention reservoir in the Grand River Basin, and would provide for pumping stored water from the retention reservoir back into the Mahoning River above Warren for purposes of low-flow augmentation. Thus, the extremes of flood and drought in the Mahoning River would be greatly modified.

Flow regulation, with the augmentation of drought flows, would appreciably raise minimum expected flow levels in the critical stretch of the Mahoning River during periods of low rainfall and runoff. These increased flows would be of decided assistance in supplementing partial treatment of sewage and industrial wastes now discharging into the Mahoning River. Reductions in river temperatures below Warren, Ohio, would have considerable value to the numerous steel and power plants located in the area. Other benefits to industry, such as reduced hardness of river water and improved water quality, would be appreciable. Minimum expected flows in the Grand River at Painesville would be raised, with resulting organic pollution abatement benefits in that stream.

CONCLUSIONS

1. Under conditions of regulated flow possible in the Mahoning River after construction of Milton Reservoir but prior to the construction of Berlin and Mosquito Reservoirs, the minimum expected flow at Youngstown, Ohio, was 145 c.f.s. during the summer months and 110 c.f.s. in the winter. Nuisance conditions existed frequently in the stream in the Youngstown area. In order to maintain a minimum dissolved oxygen level of three parts per million at these flow levels, it would have been necessary to remove approximately 90 percent of the present combined municipal and industrial organic pollution load from the Youngstown area by treatment prior to discharge into the stream.

2. Under flow conditions given in the current operation schedule for Berlin and Mosquito Creek reservoirs, the minimum monthly average flows at Youngstown will be 470 c.f.s. in July and 185 c.f.s. during winter months, with a minimum yearly average flow of 275 c.f.s. Under the current reservoir operation schedules, it is estimated that intermediate treatment of municipal wastes (65 percent reduction of biochemical oxygen demand) and equivalent reduction of industrial wastes will maintain a dissolved oxygen content in the river of not less than three parts per million during the summer months. Somewhat higher reduction would be required with current minimum flow schedules during winter months. With the best monthly distribution of flow from existing available storage in relation to pollution abatement needs a slight deficiency below the desirable objective of three parts per million dissolved oxygen in the stream would exist during extreme low-flow years. Any population or industrial growth would increase the deficiency.

3. A pollution abatement program has been established for the Warren-Niles-Youngstown area which is directed toward provision of intermediate treatment (chemical or equivalent) for municipal wastes. It is expressly understood that, in the design of municipal waste treatment plants, provision shall be made for the future addition of a higher degree of treatment.

4. Treatment requirements for industrial wastes include reduction of wastes having effects other than depletion of oxygen. Such wastes include suspended solids, phenols, acids, and oils. These requirements will not be substantially reduced by increase in low flows above those which exist at present. Compliance with the requirements will be accompanied by substantial reduction in deoxygenating waste loads.

5. The addition of the Grand River reservoir, floodway, and pumping facilities will augment present flows so that cost of operating chemical treatment plants will be reduced, the anticipated need for providing higher than chemical treatment within the near future under present flow conditions will be extended beyond the foreseeable future, and a substantial factor of safety for future growth will be provided.

6. Flow increases will enter the Ohio River and will result in pollution abatement benefits downstream. Such increases will have value in raising water quality above minimum objectives. Increased flows will have a tangible value in reducing the chemical treatment requirements at Cincinnati, Ohio. Under present conditions this value is estimated to average $5.00 per year per c.f.s. increase in low flow.

7. In addition to pollution abatement benefits, increased minimum flow levels would be of considerable value to industrial plants in the Youngstown area. The largest single benefit to industry would be in the form of reduced river water temperatures at industrial intakes, which would permit more efficient operation. Improvements in water quality would also be of material benefit to industry, and reduced hardness of river water would make substantial savings possible. Other industrial benefits which would occur include reduced expenditures for purchased water and power, increased by-product recovery, and reduced water pumpage.

8. Flow releases to the Grand River would reduce sewage treatment requirements at Painesville, Ohio, from secondary to primary.

9. The total annual monetary benefits, exclusive of flood control benefits, attributable to each phase of the water resources development program, based on June, 1953 cost levels, are estimated as follows:

Benefit	Estimated Total Annual Monetary Benefit	
	At Present Flows	With Floodway, Grand River Res., and Pumping
Organic Pollution Abatement (Primarily municipal and connected industrial wastes)		
(a) Mahoning River	225,800	428,300
(b) Ohio River	25,800	27,800
(c) Grand River	-	23,600
Municipal Water Supply	50,800	50,800
Industrial:		
Temperature Reduction		
Hardness Reduction		
Reduced Maintenance, Repair and Replacement		
Other		
Total		

DESCRIPTION

General

Water resources developments considered in this study include the existing Berlin, Milton, and Mosquito Creek reservoirs and the proposed Grand River reservoir, floodway, and pumping facilities. Pertinent features of existing and proposed projects are described in the basic report of the Corps of Engineers.

The benefits from improved water quality resulting from existing and proposed water resources developments in the Mahoning River basin occur, principally, in the Mahoning River in the Warren to Lowellville section of the river. Some organic pollution abatement benefits will occur in the Grand River. Increased low flows in the Mahoning River carry downstream through the Beaver River to the Ohio River, and, together with flow regulation from other reservoirs in the Ohio River basin, have pollution abatement benefits in the Ohio River.

In calculating monetary benefits resulting from flow regulation, it is emphasized that dilution is regarded as a supplement to and not a replacement for sewage treatment. The value of such benefits is assumed to equal the savings in sewage treatment costs which can be realized because increased flows will reduce the degree of treatment necessary to maintain a specified water quality objective.

Water Supply

Water supply for Warren, now taken from the Mahoning River, will soon be obtained from Mosquito Creek reservoir. No other municipal water supply is obtained from the Mahoning River proper in or below the heavily industrialized Warren-Niles-Youngstown area.

The most important present use of the Mahoning River is as a source of industrial water supply. A substantial portion of the nation's steel is produced in the Youngstown area, and the river is the principal source of water supply for the steel and power plants. It is estimated that present peak industrial water use is 1220 million gallons per day or an average of 1887 c.f.s. - many times the flow in the river during low-flow periods. The shortage of water which occurs regularly seriously affects industrial plant efficiencies

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throughout the critical reach, and regulation would be of great value to industry.

Sources of Pollution

Sewage and industrial wastes from cities and industries located along the Mahoning River are discharged to the stream without treatment.

A comprehensive stream sanitation survey of the Mahoning River was conducted by the Ohio State Department of Health in 1952 from May to November, inclusive. The survey data show that, based on biochemical oxygen demand, the waste loads discharged through municipal sewerage systems and industrial outfalls in the Warren to Lowellville section of the Mahoning River have population equivalent values of 296, 300 and 103, 500, respectively. The load from municipal systems includes tributary industrial loads. In addition to the deoxygenating wastes, polluting substances of industrial origin include phenols, oils, acids, and settleable solids. Approximately 372, 500 pounds of free acid (as $CaCO_3$) are discharged daily. Measured phenol loads at the time of the survey totaled over 3, 000 pounds per day, most of which originated with the steel industry. Action has been initiated by the steel industry to abate pollution in compliance with the State's water pollution abatement program. There is recent evidence that operation changes have already resulted in substantial reductions in phenols. Additional reductions are contemplated.

Virtually all of the municipalities concerned are making progress toward the construction of sewage treatment plants. Treatment of municipal wastes to remove 65 percent of the biochemical oxygen demand is considered by the State regulatory agency to be a minimum objective, with the additional requirement that provisions shall be made for a higher degree of treatment in the future.

ANNUAL MONETARY BENEFITS

Organic Pollution Abatement

Water temperature is of particular significance in the analysis of pollution abatement requirements for the Mahoning River because of industrial cooling water uses. Extensive studies of temperature-flow relations were made by Public Health Service and Corps of Engineers personnel, in cooperation with industrial representatives, in connection with the December 1949 report referred to previously. Those studies provide the basis for temperature-flow relations used in this report.

Data from the survey conducted by the Ohio State Health Department in 1952 form the bases for evaluating the effects of existing pollution and the self-purification characteristics of the River.

Prior to the construction of Berlin and Mosquito Creek reservoirs, the highest average monthly flows which could be assured in low flow years were 145 c.f.s. and 110 c.f.s. in summer and winter months, respectively. The 1952 survey data show that, in order to prevent the frequent recurrence of nuisance conditions with flows regulated by Milton reservoir only, it would be necessary to remove at least 90 percent of the total municipal and industrial organic waste load now being discharged to the River. Ordinarily, for estimating purposes, secondary (biological) treatment plants are assumed to remove an average of 85 percent of the biochemical oxygen demand. However, 90 percent can be removed without resorting to extraordinary or infeasible treatment methods. The presence of large quantities of industrial wastes complicates the problem. At this time, with increased flows from Berlin and Mosquito Creek reservoirs, the question of treatment needed with Milton reservoir is of significance only with respect to benefits due to increased flow. For the purposes of estimating costs and benefits in this report, it is assumed that 90 percent of the industrial organic waste load could also be removed by process changes or treatment methods which are used by similar industries at other localities.

Under the current plan of operation for Berlin and Mosquito Creek reservoirs, a minimum flow of 470 c.f.s. will be provided at Youngstown in July and 185 c.f.s. in winter months. Minimum flows during other months will have rates between the summer peak and winter low. An analysis was made of organic pollution abatement requirements under these flow conditions

and with present waste loads, using the 1952 stream survey data referred to previously. The analysis indicates that a minimum dissolved oxygen content of three parts per million will be maintained in the River during summer months with the current flow schedule, provided the organic waste load is reduced by 65 percent before discharge to the River. Some deficiency below the desirable dissolved oxygen objective would exist in the winter months with the same degree of treatment and the current operating schedule in low flow years. With the best monthly flow distribution from available storage only a slight deficiency below the objective of not less than three parts per million dissolved oxygen would result.

The current operation schedule may be affected by commitments to furnish water to the Mahoning Valley Sanitary District from Berlin reservoir. Inasmuch as the critical stretch of the River with respect to pollution abatement needs is below Youngstown, it is assumed that the major part of any flow diverted to the District will return to the River above the critical section.

A study of actual flow records since the present reservoirs were installed reveals that flows exceeded the minimum schedule to the extent that primary treatment would have been satisfactory under present flow conditions for an average of five months out of each year. A higher degree of treatment would have been needed during the remaining seven months.

It should be emphasized that, although present flow control structures make it possible to maintain minimum dissolved oxygen objectives with chemical treatment (65 percent biochemical oxygen demand reduction) there is no factor of safety for future municipal or industrial growth.

With the floodway, Grand River Reservoir, and the pumping facilities, reliable minimum monthly average flows at Youngstown of 755 and 290 c.f.s. could be maintained during July and January, respectively. Minimum rates of flow during other months would have values between the July and January rates. The increased flow would have substantial value in reducing the cost of sewage treatment. The program of the Ohio Water Pollution Control Board calls for sewage treatment capable of reducing deoxygenating wastes by at least 65 percent (chemical treatment or equivalent) during critical flow periods. The increased flows from the Grand River development would, to a great extent, reduce the time when more than primary treatment would be needed. Operating costs at contemplated chemical treatment plants would be substantially reduced by the increased flows. An additional benefit concerns the probable need for secondary treatment within foreseeable future under present flow conditions. Increased flows will extend this need farther into the future.

It is customary practice to amortize the life of reservoir projects over a longer period of years than is customary for sewage treatment plants. In

this instance 50 years is the estimated life of the reservoir project and 20 years the life of sewage treatment plants. This is of particular significance because of the change in bases for computing benefits which will occur with any substantial pollution load increases. It is not unreasonable to assume that such an increase will occur within a 20-year period. Accordingly, estimates of benefits are based on present conditions for the first 20 years and 20 percent increase in waste loads for the rest of the assumed life of the reservoir projects. In both instances a design factor has been added in estimating construction costs.

The bases for computing flow regulation benefits are summarized, from the preceding discussion, as follows:

a. The existing Berlin and Mosquito Creek reservoirs make it possible to lower treatment requirements under present load conditions from about 90 percent removal of biochemical oxygen demand to 65 percent removal. Benefits attributed to the reservoirs are based on the difference between secondary and chemical treatment costs. This condition is assumed to prevail for the first 20 years of the reservoir project life.

b. For the second period of the life of the project pollution loads are assumed to be increased by 20 percent. Under this condition an extremely high degree of secondary treatment would be required without Berlin and Mosquito Creek reservoirs and secondary treatment would be required with them.

c. The floodway, Grand River reservoir, and pumping would greatly reduce the time of operation required for chemical treatment plants along the Mahoning River under present load and flow conditions. Benefits for the first 20 years are based on the savings in chemicals but do not include allowance for savings in capital or maintenance costs.

d. For the second period of the life of the project secondary treatment would be required without the Grand River reservoir. Chemical treatment, with application of chemicals required only a small part of the time, would still be sufficient with the reservoir.

e. Increased low flow in the Grand River, made feasible by releases from the proposed reservoir, would reduce sewage treatment requirements at Painesville, Ohio, from secondary to primary treatment. Benefits are estimated on the basis of the difference in cost between those degrees of treatment.

Annual monetary benefits attributed to low flow control are contingent upon provision of the degree of waste treatment required under flow conditions considered and are further contingent upon compatibility of reservoir and pollution abatement programs with respect to timing and assurance of construction. In this instance, as well as other instances in the Ohio River basin, progress in pollution abatement planning in advance of reservoir developments previously considered has altered the basis on which low flow regulation benefits are computed.

Practically all of the municipalities in the section of the Mahoning River affected by this report have detailed plans or reports, with estimates of cost, for treatment required under existing flow conditions. These have been adjusted to the common cost index of June 1953 and used as a basis for cost estimates. Most of the designs are for chemical treatment and all are designed to meet the objective of 65 percent biochemical oxygen demand removal. Estimates of cost for primary and secondary treatment plants, for comparison purposes, were derived by several methods, including: deductions and additions to the chemical plant estimates; studies of estimates in the Cincinnati area, for which estimates based on detailed plans for both primary and chemical treatment plants were available; data from previous studies of treatment costs in the Ohio River basin; and other sources. Operation cost studies included consideration of consulting engineer's estimates and numerous annual reports of actual operation costs. The total annual charges for each type of operation is the sum of the annual operation and maintenance charges and the amortization and interest charges for the capital investment. Because of changing conditions in waste treatment requirements during the useful life of the reservoir project, organic pollution abatement benefits are computed for two periods and then adjusted to a uniform annual benefit over the useful life of the reservoir. Capital costs of sewage treatment plants are assumed to be amortized over a period of 20 years at 2.5 percent interest.

No separate allowance has been made for benefits to organic industrial pollution abatement. The only major source of such wastes, other than wastes included in the designs for municipal plants, originate with the steel industry. Pollution problems of this industry have to do with wastes principally troublesome for reasons other than deoxygenation. Recent studies of steel industry wastes by the Public Health Service (Environmental Health Center) and field investigations of actual operation show that pollution abatement measures in practice elsewhere can provide substantial reduction of troublesome wastes. Application of these measures, or equivalent, in the Mahoning Valley are advisable regardless of increased flow regulation under consideration. Control of deoxygenating wastes has accompanied control of other types of waste, to the extent that they would not be of great significance if the control measures were applied in the Mahoning Valley. For this reason allocation

of benefits to organic pollution abatement from increased flow regulation is not considered warranted. Some benefit of increased flows, possibly substantial, would result from greater dilution of final residual phenol loads and other types of waste.

Total organic pollution abatement benefits, estimated in accordance with the preceding discussion, are tabulated in the following table:

POLLUTION ABATEMENT BENEFITS DUE TO FLOW REGULATION

Flow Condition	ANNUAL MONETARY BENEFITS			
	Mahoning R.	Grand R.	Ohio R.	Total
Present	225,800	-	25,800	251,600
With Floodway, Grand River Reservoir, and Pumping	428,300	23,600	27,800	479,700

Hardness Reduction (Municipal)

Considerable amounts of hardness are added to the Mahoning River throughout its course, especially from Warren to the State line, in the form of waste pickle liquor and lime. There is not only an increase in the total hardness, but the non-carbonate hardness is also increased with a corresponding reduction in alkalinity and carbonate hardness.

Previous reports had assigned monetary benefits for hardness reduction to the public water supply at Warren, Ohio, which purified and softened Mahoning River water. That city has since entered into a contract with the Government to purchase water from Mosquito Creek Reservoir, and a new water purification plant and necessary pipe lines are now under construction to utilize this source. Therefore, savings in water softening chemicals for treating Mahoning River water are no longer applicable.

Some minor monetary benefits were also assigned to soap savings at Beaver Falls and New Brighton, Pennsylvania, as a result of hardness reduction in the Mahoning River which unites with the Shenango River to form the Beaver, the source of supply for these two Pennsylvania communities. A review of this situation indicates that the greatly increased use of detergents in the past ten

or twelve years has reduced the costs previously associated with increased soap consumption in hard waters. Because of these factors, monetary benefits attributable to reduction in hardness of domestic water supplies are not of great significance in justification of the reservoir projects. Accordingly, no monetary benefits for this purpose are assigned.

Industrial Benefits

Improvements in water quality have a variety of benefits to industry. These include benefits due to: temperature reduction; reduced maintenance, repair, and replacement; hardness reduction; reduced purchased water; reduced purchased power; increased by-products recovery; and reduced water pumpage. Detailed studies and estimates of these benefits were made jointly by Public Health Service and Corps of Engineers representatives, in cooperation with industrial representatives, for the 1949 report previously referred to. For this review report, Corps of Engineers representatives conferred with industry to determine whether basic conditions existing at the time previous estimates were made were still applicable. As a result it was concluded that previous estimates of benefits, adjusted to reflect cost changes applicable to the various items, were appropriate for this review report. Cost adjustments have been made by Corps of Engineers representatives.

For convenience of reference and to show the bases for and scope of benefits, extracts from the 1949 report by the Public Health Service, applicable to the indicated benefit items, are quoted below:

Temperature Reduction

"The Mahoning River Valley in the vicinity of Warren and Youngstown, Ohio, is a highly industrialized area in which a substantial percentage of the nation's steel is produced. The Mahoning River serves as the principal source of industrial water supply for the various steel mills and power companies. It is estimated that at the present time water consumption for industrial uses totals approximately 1220 million gallons per day, and during periods of low river flow the water is used and re-used a number of times as it progresses downstream. This shortage of water during periods of low flow, together with the consequent raising of river water temperatures to levels far above normal, seriously affects industrial plant efficiencies throughout the entire reach. Consequently, reliable flow increases due to regulation will be a decided benefit to industry, in the form of increased amounts of available cooling water at reduced temperatures.

"In 1941, in connection with a report on Berlin Reservoir, (1) this office made an analysis of the temperature-flow relationship in the Mahoning River, pointing out, however, the lack of sufficient data for a complete and final analysis. In recent years, more information, especially with regard to observed river conditions, has become available, and a re-evaluation of the temperature-flow relationship in the stream was therefore undertaken.

"Upstream from the first major industrial plant in the critical reach, there is little or no excess river water temperature over the average air temperature. At the first plant, heat is added to the stream, and, just downstream from the plant, river temperature is somewhat higher than normal. In traveling downstream to the next plant, a portion of this excess heat is lost to the atmosphere. At the second plant the stream again receives an increment of heat, and in progressing downstream some of the excess temperature is again lost. This process of alternate gain and loss of heat is carried on throughout the entire critical stretch, and, during periods of low flow, water intake temperatures at downstream plants may be very far above normal. Given adequate information regarding the amount of heat added to the stream by each industry, and applying a proper factor for heat loss to the atmosphere, it is possible to calculate temperature traverses throughout the reach at various flow levels, and to define the relationship between flow and excess temperature at any location along the stream.

.....

"Information regarding heat added by industry and industrial water consumption was correlated with actual steel production, a proper heat loss factor was selected by trial and error, and temperature traverses were computed at several flow levels, as well as for air temperatures of 50° F. and 75° F. and steel production levels of 80 percent and 100 percent of capacity. The resulting excess temperature profiles were then used for the construction of curves defining the relation between excess temperature and flow at each industrial water intake. Checks between computed and observed temperatures at several locations along the stream were quite good, and the curves have therefore been used for purposes of estimating the reduction in excess temperature which would result due to increased minimum flow levels in the stream. Each phase of the flow regulation program will provide a known increase in the minimum flow level, and the resulting water temperature reduction at any industrial intake may be taken from the temperature flow curve for that intake.

"Annual monetary benefits to industry due to reduced water temperatures are based upon the resulting reduction in coal consumption. Lower industrial water temperatures are reflected in the creation of a better vacuum at the plant condensers, which results in reduced steam consumption. As coal costs are directly related to steam consumption, the improved efficiency due to regulation may be expressed as dollars saved on coal expenditures.

"As is the case with other benefits, temperature reduction benefits include the problem of diminishing returns. For each additional unit of reliable flow which is provided by regulation, the monetary benefit due to temperature reduction becomes slightly lower. The first additional flow increment, therefore, has the greatest value, and a theoretical flow could be reached at which there would be no additional benefits for temperature reduction. In the case of the proposed regulation program in the Mahoning River Valley, each of the planned flow increases would result in a definite and appreciable benefit to industry for temperature reduction .. ..
.....

"Based upon actual operating records and the expected changes in flow and temperature due to regulation, the various industries concerned have furnished detailed estimates of the annual monetary benefits to be expected from each phase of the regulation program. These benefits ..... are based upon coal .....
Estimates were supplied for production levels of 80 percent and 100 percent of capacity, but the tabulated benefits shown here are for the 80 percent production level, as continuous operation at a higher level over a long period of years would appear to be doubtful.

.....

Hardness Reduction

"..... Benefits to industry are in the form of decreased costs for chemicals used in water softening, ...
The various industries concerned have furnished estimates of the savings in chemical costs which will occur due to flow regulation, and these figures show good agreement with the adjusted 1941 estimates made by this office.

.....

Maintenance, Repair and Replacement (Benefits due to improved water cleanliness and increased supply)

"The necessity for frequent cleaning, repair and replacement of pipe lines, valves and other industrial plant equipment which is exposed to untreated river water is a major operating problem to steel plants in the Mahoning River Valley. Recent investigation and consultation with plant officials indicates that the frequency of maintenance and replacement, and therefore the magnitude of the expense, is directly related to the concentration of suspended material in the raw water taken from the river. Decreases in the concentration of suspended matter which are the result of flow regulation can therefore be expressed as monetary benefits to steel plants in the form of reduced costs for maintenance and replacement of plant equipment. The annual expense to industry is large, and benefits due to improved water "cleanliness" may be appreciable.

"In addition to the direct costs of maintenance and repair of the above type of plant equipment, the required frequency of such plant housekeeping, and the consequent frequency of shutdown of production units, can be a limiting factor on plant output. In other terms, a decided reduction in the concentration of suspended matter in the river water would reduce the necessary frequency of maintenance and replacement, and would therefore permit less interruption of production operations. However, due to the multiplicity of factors which affect steel production, no attempt to evaluate this benefit has been made.

"It is to be expected that the proposed flow regulation program will result in somewhat reduced concentrations of suspended matter at industrial intakes, with resulting benefits to industry in the form of reduced costs for maintenance and replacement of plant equipment. However, a large part of the suspended load in the stream, especially in the Youngstown area, consists of slag and fly ash discharged by the steel plants themselves. If these waste discharges are continued in the future, a fairly high concentration of suspended matter will be maintained despite flow regulation. In addition, the deposition of these solids on the river bottom in reaches of low stream velocity will steadily reduce river depths in the deposit area, thereby offsetting a part of the protection against flood damage which is to be provided by regulation.

"To large steel plants which have been able to obtain only a seriously limited supply of water, increases in the amount of water available as a result of flow regulation can be of considerable value. For example, officials from one steel plant report that, due to the

increased quantity of water which became available with the construction of Berlin and Mosquito Reservoirs, it was possible to install coolers on the front walls of eight open-hearth furnaces. It was estimated that the use of these coolers doubled the life of each front wall, and resulted in an annual saving of $120,000 at this steel plant. Although this was the only plant to report monetary benefits in this category, it is probable that with the construction of the floodway and pumping facilities further such economies would be possible at this and other plants. Although it is believed that real benefits may be realized, no attempt has been made to evaluate the benefits to other plants of increased quantities of available water, as there is no available information upon which to base an evaluation.

"The following table is a summary of total annual monetary benefits to industry due to the improved water "cleanliness" and increased available supply which would result from flow regulation. These figures were derived from detailed estimates submitted by each of the industrial plants concerned, and represent plant operation at 80 percent of production capacity:

.....

Other

"As a result of high river water temperatures at coke plants in the Mahoning River Valley, it has been necessary in the past to recover light oils as motor fuel or ship elsewhere for light oil recovery. With flow regulation, lower river water temperatures at the coke plants would permit more efficient light oil recovery, with resulting monetary gain. The total annual monetary benefits for better by-product recovery have been estimated by industrial plant officials, and are shown in the following table.

"In order to permit normal operation throughout the year, the various steel plants have found it necessary to purchase water and/or power from private companies at considerable annual cost, due to insufficient river flow during a part of the year. It is estimated that each phase of the proposed flow regulation program would permit reductions in purchases of water and power, thereby resulting in a saving to industry in the form of reduced costs for purchased water or power. The various industries concerned have submitted estimates of the expected savings, and the following table contains a summary of their estimates.

"Finally, in certain cases a benefit due to reduced cooling water pumpage will be realized. As a result of flow regulation, river water temperatures will be lower, and each unit volume of cooling water used will be able to absorb more heat. Assuming that the average amount of heat which must be absorbed by cooling water is relatively constant, it follows that cooling water consumption will be reduced by regulation, and there will be a saving in the cost of pumping cooling water.

....."

Industrial benefits, adjusted to reflect June, 1953, values are tabulated as follows:

INDUSTRIAL BENEFITS DUE TO FLOW REGULATION

Item of Benefit	Flow Condition	
	Present	With Floodway, Grand River Reservoir, and Pumping
Temperature Reduction		
Hardness Reduction		
Reduced Maintenance		
Repair and Replacement		
Other		
Total		

Public Water Supplies

Agreements have been made for the City of Warren to obtain a public water supply from Mosquito Creek reservoir. A similar agreement has been made to augment the Mahoning Valley Sanitary District Water supply from Berlin reservoir. Based on unit prices and estimated demands contained in the agreements, these supplies have an annual value of $50,800 per year.